# The Emergence of Spacecraft Autonomy

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Abstract: The development of autonomy technologies is the key to three vastly important strategic technical challenges facing NASA: the reduction of mission costs, the continuing return of quality science products through limited communications bandwidth, and the launching of a new era of solar system exploration -- beyond reconnaissance -- characterized by sustained presence and in-depth scientific studies.

Autonomy can reduce mission costs in multiple ways: 1) by migrating routine, traditionally ground-based functions to the spacecraft, 2) by directly supporting the decoupling of space platforms from the ground through new operations concepts, 3) by supporting direct links between scientists and the space platforms carrying their instruments of investigation, and 4), via the closing of planning and control loops onboard, enabling the space platform to directly address uncertainty in the real-time mission context.

Autonomy is the central capability for enabling long-term scientific studies of a decade or more -- currently prohibited by cost and lack of self-reliance on space platforms -- and for enabling new classes of missions which inherently must be executed without the benefit of ground support, either due to control challenges, e.g., small body rendezvous and landing missions, or due to planning challenges which arise from the impossibility of communication for long periods, e.g., a Europan under-ice explorer, or a Titan aerobot.

The need for autonomy technology is nowhere greater than in the set of deep space planetary missions which JPL conducts for NASA. The extreme remoteness of the targets, the impossibility of hands-on troubleshooting, and the difficulties of light-time delayed communication all contribute to make JPL science missions the focus for the development and application of spacecraft autonomy technology.